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THORACICAN CIRRIPEDIA OF THE LOWER PLIOCENE PANTO RICO
FORMATION, SALINAS VALLEY, MONTEREY COUNTY, CALIFORNIA

By Victor A. Zullo



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The *Science Bulletin* and *Contributions in Science* of the Natural History Museum of Los Angeles County were merged into a single imperial octavo serial, retaining the name *Contributions in Science* and beginning with Number 301.

This serial has been newly formatted for maximum use of typography and illustrations per page, and sized for maximum use of paper. All photography has been produced utilizing a 200-line screen for detail.

Since most institutions rebind *Contributions in Science* collectively into hardbound volumes, and many researchers using them desire to photocopy material, two new features have been incorporated into the new format. A suggested citation line provides the abbreviated serial title, year, number of publication, and total pagination, and appears in the lower left corner of each page; and pages of *Contributions in Science* have been printed off-center to provide a two-inch gutter between adjacent pages for easier accessibility in photocopying.

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THORACICAN CIRRIPIEDIA OF THE LOWER PLIOCENE PANCHO RICO FORMATION, SALINAS VALLEY, MONTEREY COUNTY, CALIFORNIA¹

By Victor A. Zullo²

ABSTRACT: Five thoracican barnacles, including *Balanus gregarius* (Conrad 1856), *B. proinus* Woodring 1950, and three new taxa, *B. proxinubilis*, *B. addicotti*, and *B. crenatus leipochooma*, were found in association with a nearshore warm temperate molluscan fauna. *Balanus proxinubilis*, which also occurs in the Upper Pliocene San Diego Formation, is related to the extant Pacific Coast species *B. nubilus* Darwin 1854. *Balanus addicotti* is allied to the extant pantropical species *B. trigonus* Darwin 1854, and *B. crenatus leipochooma* differs but slightly from extant *B. crenatus* Bruguière 1789. The Pancho Rico occurrence of *B. proinus* represents the oldest known record of this southern California Pliocene species.

The Pancho Rico Formation is of interest to students of fossil Cirripedia in that it is probably the type locality for *Balanus* (*Balanus*) *gregarius* (Conrad 1856). As first described by Conrad (1856, 1857a), this large and unusual barnacle was indicated as having been collected in Monterey County by A.S. Taylor, an early resident of Monterey. Except for its presence in the northernmost outcrops of the Upper Miocene Santa Margarita Formation near Vineyard Canyon, *B. gregarius* is known in Monterey County only from the Pancho Rico Formation (text figure 1). Its conspicuousness and abundance at several easily accessible localities in a part of the Salinas Valley that was populated during Taylor's lifetime strongly suggest that the original specimen came from the Pancho Rico, rather than the more southerly and limited exposures of the Santa Margarita. The type specimen, which presumably would have been deposited in the Academy of Natural Sciences of Philadelphia, has not been located and is probably lost.

The Lower Pliocene Pancho Rico Formation as redefined by Durham and Addicott (1964, 1965) is characterized by fine grained sandstone and lesser amounts of conglomerate and mudstone overlying Late Miocene or older rocks and underlying the Pliocene or Pleistocene Paso Robles Formation. According to Addicott (*in* Durham and Addicott 1965:A 18) the molluscan fauna of the Pancho Rico Formation suggests "that the local early Pliocene marine climate was generally warmer than modern climates at comparable latitudes off the central California coast" and that "living representatives or modern analogs [of the Pancho Rico molluscan fauna] are usually found in shallow near-shore areas of the northeastern Pacific Ocean."

The barnacles available from the Pancho Rico Formation suggest environmental conditions similar to those proposed for the molluscan assemblage. Besides *B. gregarius*, four additional taxa were present in collections examined. *Balanus proinus* Woodring 1950 is an extinct species commonly encountered in younger Pliocene deposits in the San Joaquin Valley, the Santa Maria district, and in San Diego County. A new species related to *B. trigonus* Darwin 1854 was found at two localities. *Balanus*

trigonus is an extant tropical species with Pleistocene records in the Caribbean and on the Pacific side of Mexico, indicating its presence in the tropical American fauna prior to the late Miocene closure of Central American and northern South American seaways. A second new species is closely related to the extant northeastern Pacific *B. nubilus* Darwin 1854 that presently ranges from southeastern Alaska to northern Baja California, and has a fossil record extending back to at least the late Pliocene in northern California. The new subspecies is represented by seven specimens attached to a fragment of the test of a (?)schizasterid echinoid, and differs but slightly from extant *B. crenatus* Bruguière 1789, whose range on the Pacific Coast extends from the Bering Sea to Santa Barbara, California.

DESCRIPTION OF LOCALITIES

Natural History Museum of Los Angeles County, Invertebrate Paleontology Collection (LACMIP)

4660. North side of Wildhorse Canyon, NW 1/4 of SE 1/4 of Sec. 8, T. 20 S., R. 9 E., San Lucas Quadrangle. Collectors: J.A. Wolfe and V.A. Zullo, 1961 (= USGS locality M1341).

United States Geological Survey (USGS)

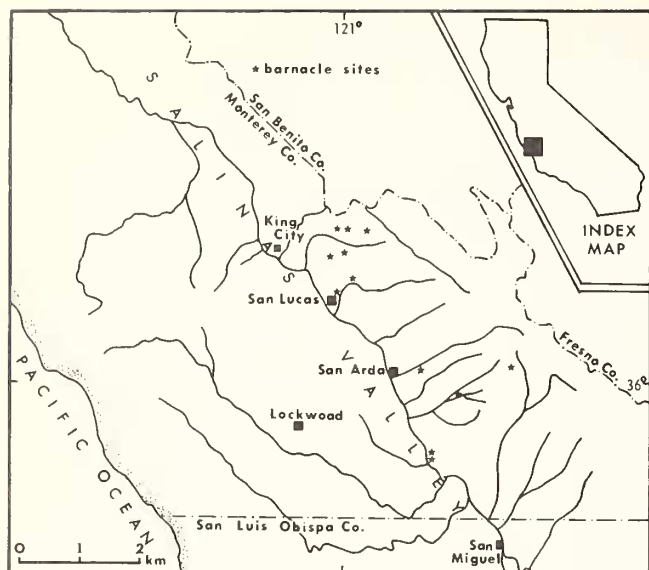
M903. Sandstone bluff on west side of State Highway 198, 425 feet south, 425 feet west of NE corner of Sec. 5, T. 21 S., R. 9 E., San Lucas quadrangle. Collectors: D.L. Durham, 1959; W.O. Addicott and D.L. Durham, 1964.

M913. North side of Wildhorse Canyon, 2650 feet north, 1075 feet east of SW corner of Sec. 8, T. 20 S., R. 9 E., San Lucas quadrangle. Collector: D.L. Durham, 1960.

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TEXT FIGURE 1. Generalized locality map of barnacle sites in the Pancho Rico Formation, Monterey County, California (adapted from Durham and Addicott 1965).

- M977. Base of bluff on south side of Pancho Rico Creek, 1000 feet north, 3100 feet west of SE corner of Sec. 11, T. 22 S., R. 10 E., San Ardo 15 minute quadrangle. Collector: D.L. Durham, 1960.
- M982. Roadcut on west side of U.S. Highway 101, 150 feet north, 2525 feet west of SE corner of Sec. 25, T. 23 S., R. 10 E., Wunpost quadrangle. Collectors: J.G. Vedder and C.A. Repenning, 1960.
- M988. 3150 feet north, 325 feet east of SE corner of Sec. 28, T. 19 S., R. 9 E., San Lucas quadrangle. Collector: D.L. Durham, 1958–59.
- M1935. North side of Walker Canyon, 900 feet north, 850 feet west of SE corner of Sec. 28, T. 22 S., R. 11 E., Wunpost quadrangle. Collectors: W.O. Addicott and D.L. Durham, 1963.
- M1970. Railroad cut at mouth of small gully, 425 feet north, 175 feet west of SE corner of Sec. 25, T. 23 S., R. 10 E., Wunpost quadrangle. Collectors: W.O. Addicott and D.L. Durham, 1964.
- M2275. Cut on north side of Bull Canyon Road, 100 feet south, 2400 feet east of NW corner of Sec. 26, T. 19 S., R. 9 E., Hernandez Valley quadrangle. Collector: W.O. Addicott, 1964.
- M2279. Float collection near head of small gully on north side of Wildhorse Canyon, 2500 feet north, 300 feet west of SE corner of Sec. 8, T. 20 S., R. 9 E., King City 15 minute quadrangle. Collector: W.O. Addicott, 1964.

University of California Museum of Paleontology (UCMP)

- A-3425. On ridge at head of Sargent Canyon, NW 1/4 corner of Sec. 9, T. 22 S., R. 12 E., Priest Valley 30 minute quadrangle.
- A-4945. Same as USGS locality 1341, LACMIP locality 4660.
- A-4947. Highest sandstone bed exposed on hill about 250 yards south-east of the center of the east half of Sec. 33, T. 20 S., R. 9 E., Priest Valley quadrangle (1915 edition).
- A-7570. East branch of prominent south draining gully; from diatomite just below contact with sandy barnacle zone, about 15 feet above lowest outcrop in cliff, NE 1/4 Sec. 32, T. 19 S., R. 9 E., King City quadrangle (1941 edition). Collected September, 1951.
- A-7571. Locality same as A-7570, but from higher bed in west branch of gully just below top of cliff.
- A-8477. Eight-tenths of a mile east of the junction of U.S. Highway 101

and State Highway 198. First outcrop on north side of Highway 198 towards Priest Valley.

SYSTEMATIC DESCRIPTIONS

Suborder BALANOMORPHA Pilsbry 1916

Family BALANIDAE Leach 1817

Genus *BALANUS* Da Costa 1778

Subgenus *BALANUS* Da Costa 1778

Balanus gregarius (Conrad 1856)

Figures 1–9

Tamiosoma gregaria Conrad 1856:315; 1857a:72, pl. 4, fig. 18 [Monterey County, California]; Gabb 1869:61, pl. 18, figs. 22a–d; Dall 1902:5.

Balanus estrellanus Conrad 1857b:195, pl. 8, fig. 1 [Estrella, California]; 1877:156.

Radiolites gregaria Conrad 1864:214.

Balanus H. estrellanus Conrad 1876:273.

?*Balanus aquila* Pilsbry 1907:199, pl. 8, figs. 5–8; 1916:127, pl. 31, figs. 1–2, 4a, pl. 32, figs. 2–2c, text figs. 34a–b, 35a–c [Monterey Bay, California].

Balanus gregarius (Conrad). Pilsbry 1916:126, pl. 28, figs. 1–3, pl. 29; Zullo 1964:360; Durham and Addicott 1965: A11, A14, pl. 1, figs. 2, 3, 6, 8 [probably not pl. 2, figs. 4, 9, referred to *Balanus* sp. on legend, pl. 2]; Zullo 1969:6, figs. 3–7, 45.

Balanus (*Tamiosoma*) cf. *B. (T.) gregarius* (Conrad). Woodring, in Woodring, Stewart and Richards 1940:96, pl. 36, figs. 2–5, 8–9.

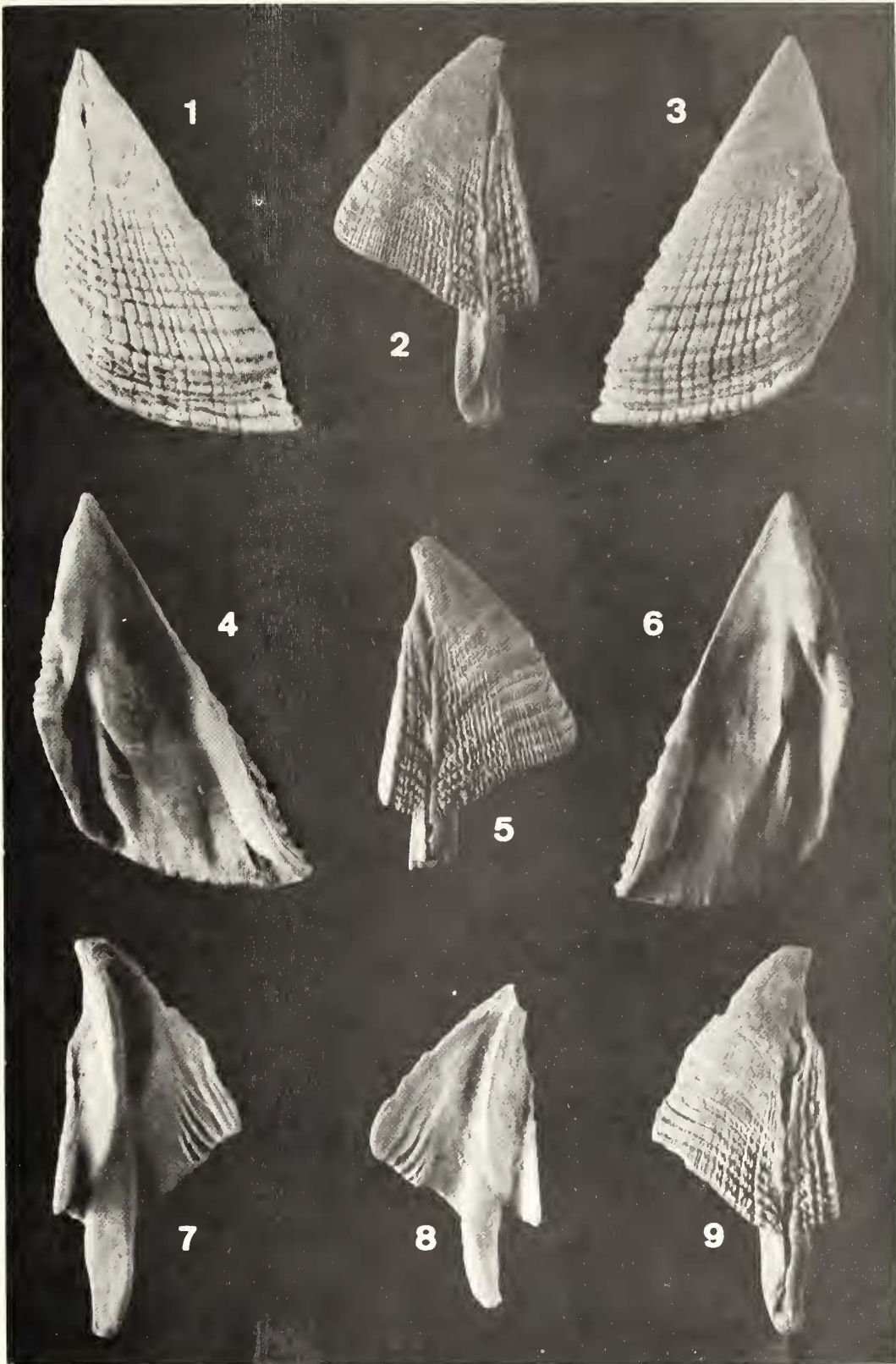
Balanus concavus concavus Bronn. Ross 1962:14, figs. 6–7.

OCCURRENCE: USGS locs. M903, M913, M977, M982, M1935, M1970; UCMP locs. A-3425, A-4945, A-7570, A-7571, A-8477; LACMIP loc. 4660.

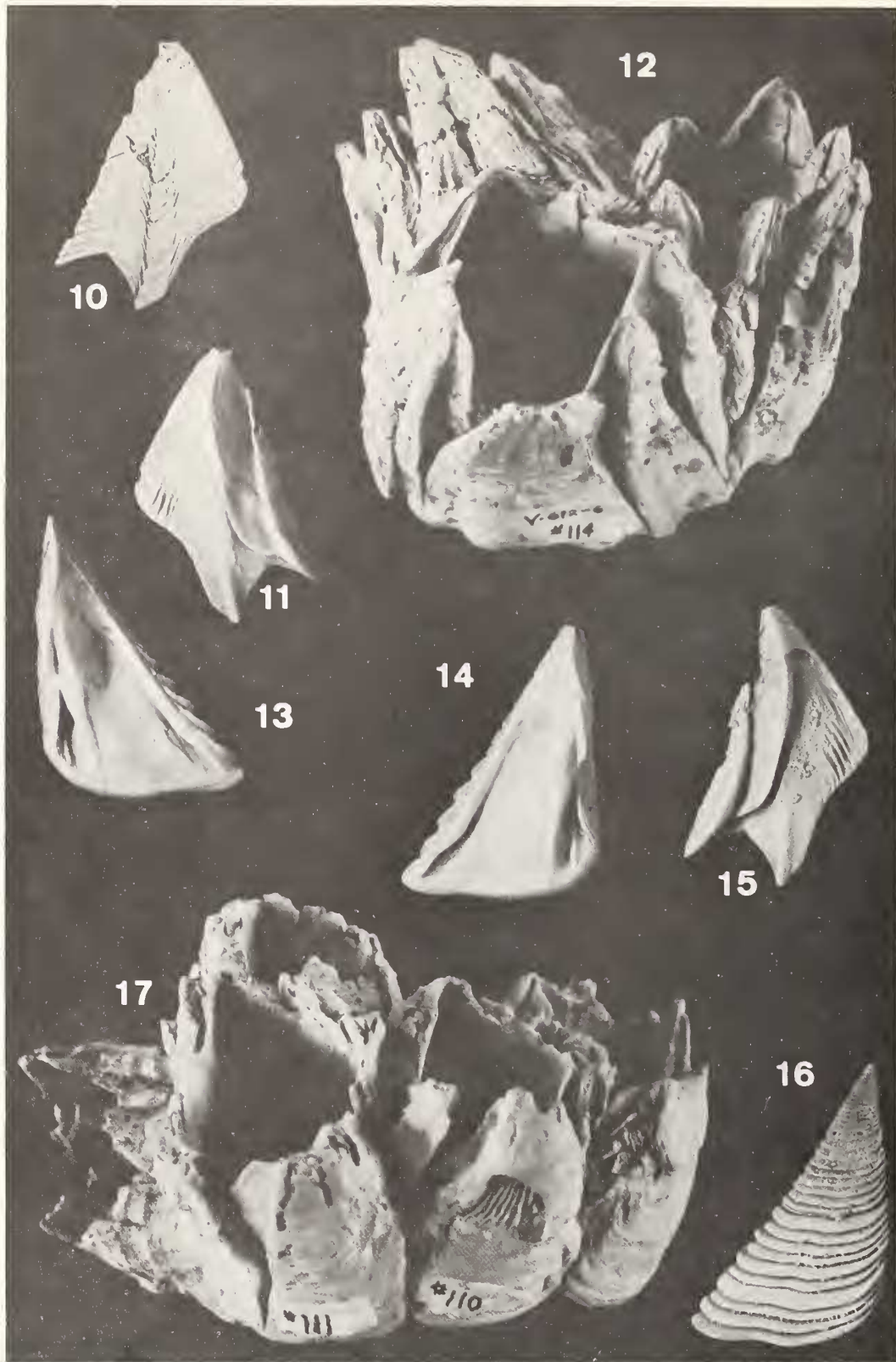
Distribution: Early Miocene—Late Pliocene, central and southern California, Baja California. (?)Pleistocene—Recent, central California to northern Baja California (as *B. aquila* Pilsbry 1907; see Zullo 1964).

REMARKS: *Balanus gregarius* is the most commonly encountered barnacle in the Pancho Rico Formation, and locally forms 'reefs' similar to those described by Woodring (in Woodring, Stewart and Richards 1940) in the Etchegoin Formation of the Kettleman Hills, Kings County, California. Preservation is excellent, and opercular valves retaining purple coloration on the beaks and in the medial part of the interior of the valve are often found either in life position or at the bottom of the sediment filled shell. About half of the Pancho Rico specimens collected lack an elongate, cellular basis. In those possessing such a basis, length (with respect to total height of shell) and density of cellular filling varied greatly. A few bases up to 35 cm in length were found, but most were in the range of from 8 to 15 cm.

Opercular valves obtained from shells with flat bases were not observed to differ from those found in shells with elongate bases. Similarly, Pancho Rico valves could not be differentiated from those previously illustrated from the Upper Pliocene San Diego Formation (Zullo 1969), or from those of Pleistocene or extant specimens of *B. aquila*. As suggested earlier (Zullo 1964), it is probable that *B. aquila* is a junior synonym of *B. gregarius*. The opercular valves of *B. gregarius* described and illustrated from the Kettleman Hills by Woodring (in Woodring, Stewart and Richards 1940) are also similar in form, but are not representative of the Etchegoin population. Bulk collections (which included over 200 opercular valves) made by the author from



FIGURES 1-9. Opercular valves of *Balanus (Balanus) gregarius* (Conrad). (1) exterior of scutum, hypotype LACMIP 4926; (2) exterior of tergum, hypotype LACMIP 4927; (3) exterior of scutum, hypotype LACMIP 4928; (4) interior of scutum, hypotype LACMIP 4929; (5) exterior of tergum, hypotype LACMIP 4930; (6) interior of scutum, hypotype LACMIP 4931; (7) interior of tergum, hypotype LACMIP 4932; (8) interior of tergum, hypotype LACMIP 4933; (9) exterior of tergum, hypotype LACMIP 4932 [Height of tergum, fig. 2, 21 mm; all valves to same scale.]



FIGURES 10-17. *Balanus (Balanus) proxinubilis*, new species. (10) exterior of tergum, holotype LACMIP 4934, height, 18 mm; (11) interior of same; (12) three shells of ribbed form, paratypes LACMIP 4937, 4938, 4940, carinorostral diameter of orifice, paratype LACMIP 4938 (center of photograph), 29 mm; (13) interior of scutum, holotype LACMIP 4934, height, 20 mm; (14) interior of scutum, holotype LACMIP 4934, height, 19 mm; (15) interior of tergum, holotype LACMIP 4934, height, 19 mm; (16) exterior of scutum shown in fig. 13; (17) shells of smooth form, including holotype LACMIP 4934 (second from right) and paratypes 4935, 4936, 4941, 4942, carinorostral diameter of orifice of paratype LACMIP 4935 (second from left), 27 mm.

Woodring's localities indicate that the Etchegoin population differs in two respects: 1) the tergal spur usually is flush with the basal margin, rather than being elevated above the basal margin by the closure of the spur furrow; and 2) the articular ridge of the scutum usually is joined to the adductor ridge, rather than being clearly separated. These differences are not constant, even in specimens from the same lot, but they suggest the possibility of the presence of a distinct race of *B. gregarius* in the San Joaquin embayment during Pliocene time.

The tergum figured by Durham and Addicott (1965, pl. 2, figs. 4, 9) from the Pancho Rico Formation was referred to *B. gregarius* in the text and to *Balanus* sp. in the plate legend. The specimen does not appear to represent a tergum of *B. gregarius*. The characteristic apical beak is missing, and the apex is neither broken nor significantly worn. There is no pit entering the apex on the carinal side of the articular ridge, the exterior surface of the valve lacks radial striae (especially prominent on the scutal side in *B. gregarius*), and the tergal spur is shorter and broader. In general form this tergum resembles those of either the *B. pacificus* Pilsbry 1916—*B. concavus* Bronn 1831 group, or of the subgenus *Megabalanus* Hoek 1913. An undescribed species, related to *B. pacificus* and with a similar tergum, occurs in association with *B. gregarius* in the Upper Miocene Santa Margarita Formation in San Luis Obispo County, California (UCMP collection). The megabalanid *B. wilsoni* Zullo 1969 and some ques-

tionable specimens of *B. pacificus* are found with *B. gregarius* in the Upper Pliocene San Diego Formation.

Balanus proxinubilis NEW SPECIES

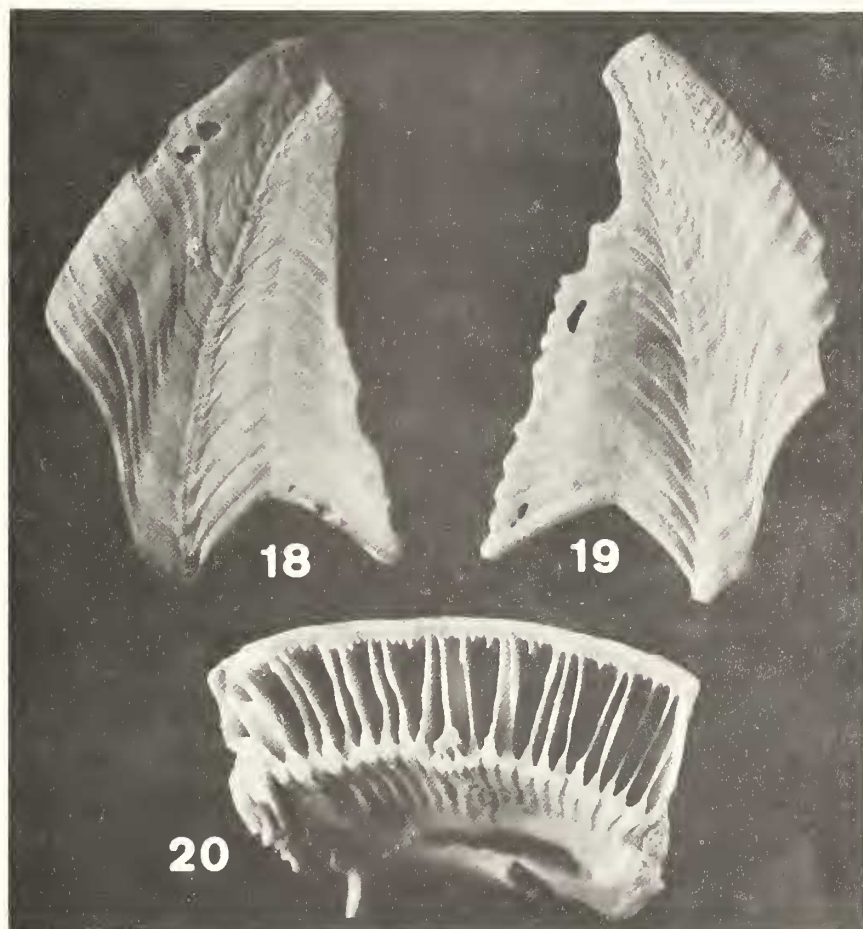
Figures 10–20

Balanus n. sp.? Addicott, in Durham and Addicott 1965:14.

Balanus nubilus Darwin. Zullo 1969:8, figs. 8–10.

DIAGNOSIS: Large, high conic *Balanus* with open parietal tubes; scutum as in *B. nubilus* Darwin, but with smaller, circular adductor muscle pit placed higher on valve, and broader, lower adductor ridge; tergum as in *B. nubilus*, but with shorter, broader tergal spur placed farther from the basiscutal angle, and resulting marked prolongation of the scutal half of the basal margin, whose juncture with the spur is angular.

DESCRIPTION: Shell large, high conic; orifice toothed, subtriangular; exterior of parietes nearly smooth to rugose; radii moderately wide with oblique summits; sutural edges of radii with complex pattern of primary and secondary denticulae; alae broad, projecting slightly above radii; basis thick, porous, clinging firmly to compartmental plates; interior of parietes ribbed from sheath to basis; sheath one-half to two-thirds length of compartmental plates, with deep cavity under lower edge; parietal tubes large, numerous, open throughout length.



FIGURES 18–20. *Balanus (Balanus) proxinubilis*, new species. (18–19) exterior of terga, paratype LACMIP 4935, height, 20 mm; (20) basal view of paries, paratype LACMIP 4939, length (from left to right), 20 mm.



FIGURES 21–22. Exterior of terga of *Balanus (Balanus) nubilus* Darwin, illustrating lack of scutal prolongation of valve (after Pilsbry 1916, pl. 31, figs. 3,4).

Scutum sculptured externally by prominent, widely spaced growth lines; tergal margin not reflected; basitergal angle nearly 90 degrees; articular ridge moderately developed, reflected, slightly over half length of tergal margin; articular furrow broad, shallow; adductor ridge indistinct, low, merging with articular ridge above to form low swelling between articular ridge and adductor muscle pit; adductor muscle pit small, well defined, circular, placed high on valve; depressor muscle pit large, triangular, with distinct longitudinal ridge bisecting pit; occludent margin bearing prominent teeth formed by alternate growth increments; tergal margin one-third again as long as basal margin; scutum slightly concave between basal margin and apex.

Tergum broad, triangular; articular ridge blunt, not reflexed, long; articular furrow broad, shallow; scutal margin prominently reflexed; crests for lateral depressor muscles well developed, thin, long, about six in number; length of basal margin equal to height of tergum excluding spur; width of tergal spur equals three-eighths length of basal margin; spur V-shaped, forming angle slightly greater than 90 degrees with basal margin on scutal side, less angulate on carinal side; spur placed centrally on basal margin (about its own width from basiscutal angle), giving an elongate appearance to scutal half of tergum; spur fasciole delimited by grooves on either side.

DIMENSIONS:	Height	Carinorostral diameter of orifice
Holotype LACMIP 4934:	37 mm	22 mm
Paratype LACMIP 4935:	50 mm	27 mm
Paratype LACMIP 4938:	54 mm	29 mm

DISPOSITION OF TYPES: Holotype and paratypes are deposited in the Invertebrate Paleontology collection, Natural History Museum of Los Angeles County.

OCCURRENCE: Lower Pliocene, Pancho Rico Formation, LACMIP locality 4660 (type locality, = UCMP loc. A-4945, USGS loc. M1341), and USGS loc. M913; Upper Pliocene, San Diego Formation, LACMIP loc. 305.

ETYMOLOGY: A compound word from the Latin, meaning nearest *nubilus*.

REMARKS: *Balanus proxinubilus* is quite similar in appearance to the extant Pacific Coast species *B. nubilus*. The shells of the two species are virtually identical in form. The scuta of *B. proxinubilus* differ somewhat in having a lower, broader adductor ridge and a smaller adductor muscle pit. The tergum of *B. proxinubilus*, however, can be distinguished readily from that of *B. nubilus*. The marked prolongation of the basiscutal part of the tergum, the short, broad tergal spur, and the angularity of the juncture between the spur and the basal margin on the scutal side give to the tergum a distinctive appearance that is not found in extant and fossil examples of *B. nubilus*.

The fragmentary terga from the Upper Pliocene San Diego Formation referred to *B. nubilus* in an earlier paper (Zullo 1969) are similar in form to the Pancho Rico terga, and also appear to represent *B. proxinubilus*. *Balanus nubilus* is known from deposits of Late Pliocene age on the Pacific Coast, but unlike *B. proxinubilus*, the species is associated with a cool water fauna in northern California. By Pleistocene time, *B. nubilus* was widely distributed, as evidenced by the numerous examples available from rocks of this age from Oregon south to Baja California. *Balanus proxinubilus* thus appears to have been a southern, warm water Pliocene species that may well have succumbed to the southern advance of *B. nubilus* during the Pleistocene.

Balanus addicotti NEW SPECIES

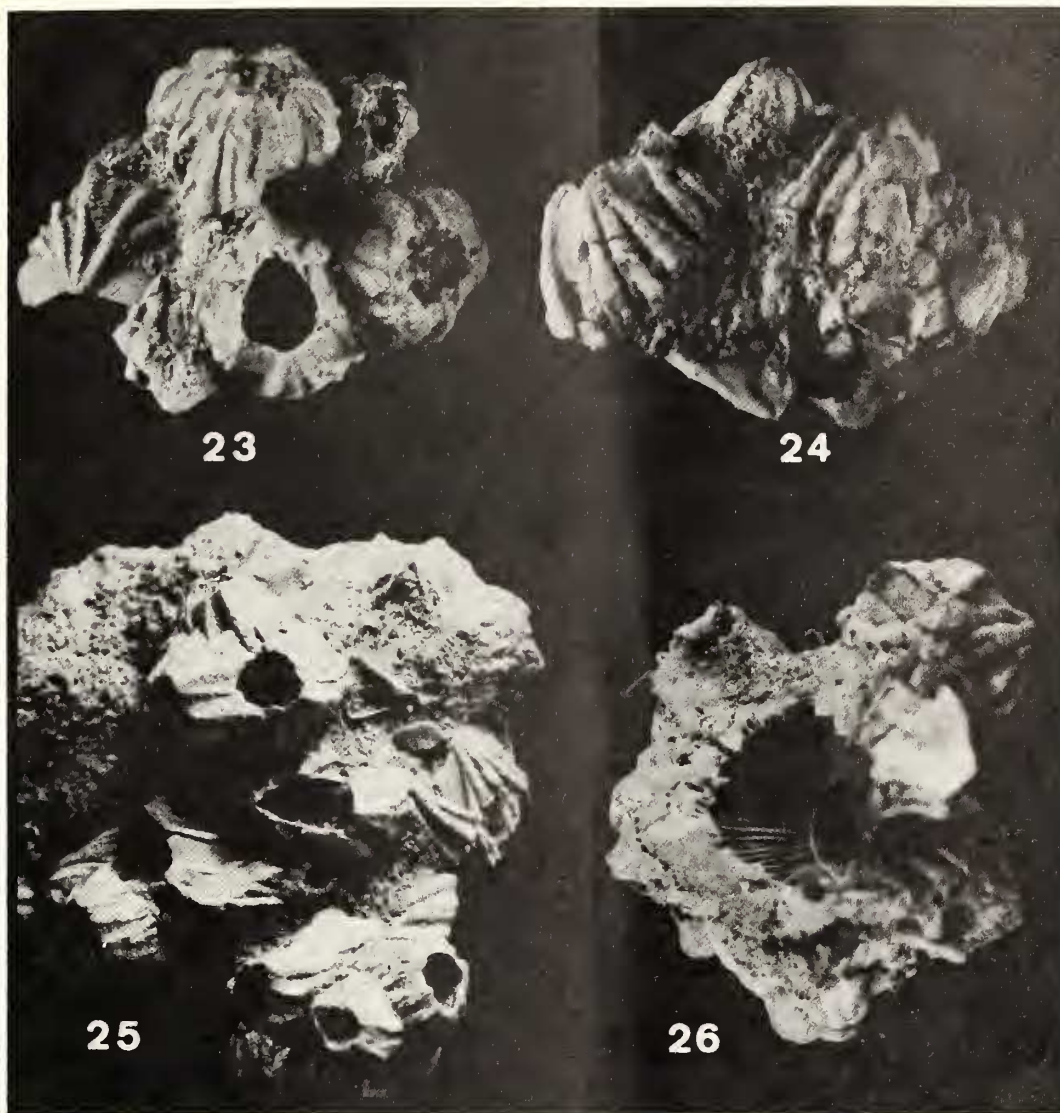
Figures 23–32

DIAGNOSIS: Small, high conic, ribbed *Balanus* with broad radii; external growth ridges of scutum cut by deep radial striae, giving marked cancellate appearance to exterior of valve; scutal adductor ridge short, stout and high; tergum with short, broad, basally truncate spur and open spur furrow.

DESCRIPTION: Shell small, high conic; orifice untoothed, subtrigonal to diamond shaped; parietes regularly ribbed; parietal tubes small, rounded, numerous, without transverse septa, but filled in upper half; radii broad, solid, thick, with horizontal summits; sutural edges of radii coarsely denticulate; alae thinner, with oblique summits; sheath about one-half height of shell, lower edge dependent; interior of parietes sharply ribbed from basis to lower edge of sheath; basis moderately thick, with small, radiating non-septate tubes.

Scutum thick, narrow; exterior ornamented by closely spaced growth ridges crossed by deeply incised radial striae that cut growth ridges into a series of high nodes; tergal border reflexed 90 degrees; adductor ridge high, short and stout, situated in center of valve, and with a small pit between it and the tergal margin; adductor muscle pit oval, shallow, situated close to occludent margin; depressor muscle pit large, deep; articular ridge two-thirds to three-fourths length of tergal margin, broadly arched, and reflexed over deep, narrow, articular furrow.

Tergum thin, broad; tergal spur short, broad, situated close to basiscutal angle, and truncate basally; spur width from one-half to two-thirds width of basal margin; juncture of spur with basal margin angular on both sides; spur furrow broad, open; articular



FIGURES 23–26. *Balanus (Balanus) addicotti*, new species, USGS loc. M1935. (23) Holotype USNM 248194 (center, bottom) and paratypes USNM 248194/a–d, carinorostral diameter of orifice of holotype, 4.5 mm; (24) group of shells, paratype lot USNM 248195, length of cluster, 21 mm; (25) group of shells, USNM 248196, maximum height of photographed portion of cluster, 35 mm; (26) interior of shell from paratype lot USNM 248195 (fig. 24) showing basal tubes, parietal ribbing, and sheath.

ridge low, short; articular furrow broad, shallow; depressor muscle crests numerous, short, dependent below basal margin.

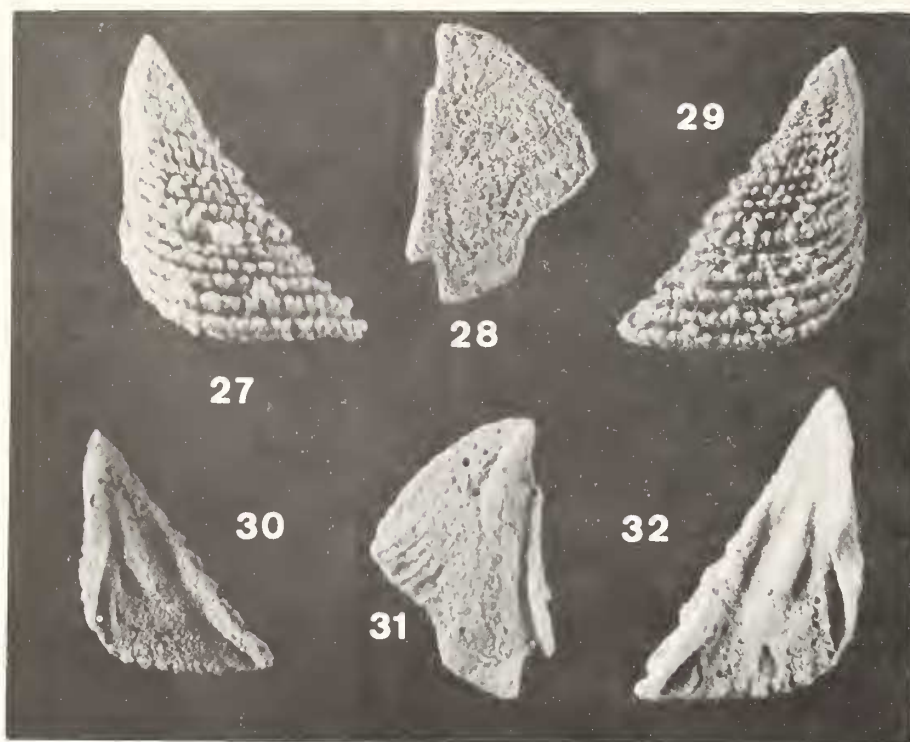
DIMENSIONS:	Height	Greatest Diameter
Holotype USNM	11 mm	9 mm
Paratype USNM 1	8 mm	12 mm
Paratype USNM 2	6.5 mm	10 mm

DISPOSITION OF TYPES: Holotype and described paratypes deposited in the United States National Museum; other paratypes deposited in the University of California Museum of Paleontology.

OCCURRENCE: Lower Pliocene, Pancho Rico Formation, USGS locs. M1935 (type locality) and M2275; UCMP loc. A-7570.

ETYMOLOGY: This species is named for Warren O. Addicott.

REMARKS: *Balanus addicotti* bears marked resemblance to the extant tropicopolitan species *B. trigonus* Darwin. It differs from this species in the less distinctly trigonal shell orifice, in the cancellate rather than pitted sculpture of the scutum, and in the stouter and more pronounced scutal adductor ridge. The cancellate ornamentation of the scutum is like that of *B. spongicola* Brown 1827, but this species differs in lacking a distinct scutal adductor ridge, and in having a much narrower tergal spur and a smooth shell wall. The opercular valves of the tropical American species *B. calidus* Pilsbry, 1916 are similar to those of *B. addicotti*, but the radial striae of the scutum of *B. calidus* are not deeply incised and thus do not impart a cancellate appearance to the surface of the valve. Also, the radii of *B. calidus* are much narrower, and the shell wall is plicate rather than regularly ribbed. *Balanus addicotti* is also similar to *B. kanakoffi* Zullo



FIGURES 27-32. Opercular valves of *Balanus (Balanus) addicotti*, new species, holotype USNM 248194, USGS loc. M1935. (27) exterior of scutum, height, 3.8 mm; (28) exterior of tergum, height, 3.5 mm; (29) exterior of scutum, height, 3.8 mm; (30) interior of scutum of fig. 29; (31) interior of tergum of fig. 28; (32) interior of scutum of fig. 27.

1969, which is known only from the Upper Pliocene San Diego Formation of southern California. However, *B. kanakoffi* has a plicate shell with narrow radii (the suture between the carina and carinolaterals being linear or obscured), and a beaked, narrow tergum. In addition the scutum of *B. kanakoffi* lacks a distinct adductor ridge.

The extant and fossil distribution of *B. trigonus* in tropical American waters indicates that this species ranged at least as far back as the Late Miocene in the eastern Pacific, and was thus probably present along the southern and central California coast during the time of deposition of the Pancho Rico Formation. *Balanus addicotti* may have been a geographically and temporally localized derivative of *B. trigonus* that became extinct upon withdrawal of the sea from the Pliocene Salinas Valley embayment. *Balanus addicotti* may yet be discovered in rocks of Jacalitos age on the eastern side of the San Andreas fault, but it does not appear to have been present in younger Pliocene warm water faunas of the San Diego Formation (Zullo 1969) and of the Etchegoin and San Joaquin Formation of the Kettleman Hills (unpublished data).

Balanus crenatus leipochoma

NEW SUBSPECIES

Figures 33-37

DIAGNOSIS: Small, low conic shell with non-septate parietal

tubes and narrow, oblique radii; interior of parietes ribbed; basis thin, nonporous; space behind dependent basal margin of sheath bearing cellular secondary deposits; scutum broader than tall, externally concave, with prominent articular ridge and indistinct adductor ridge; tergum broad, with broad, short, subtruncate spur.

DESCRIPTION: Shell small, low conic; orifice of moderate to large size, diamond shaped; parietes thin, smooth, or plicate in basal third; parietal tubes square, without transverse septa; radii narrow, oblique; alae wider than radii and projecting above summits of radii; sheath one-half to two-thirds length of compartment; space under lower edge of sheath crudely septate or secondarily filled; interior of parietes ribbed; basis thin, solid.

External surface of scutum concave, ornamented solely by growth increments; basal margin slightly longer than tergal margin; articular ridge prominent, nearly erect, occupying slightly more than half of the tergal margin, articular furrow deep, broad; adductor ridge indistinct, basically a calloused region between adductor muscle pit and articular ridge; adductor muscle pit prominent, deep, lenticular in shape; depressor muscle pit shallow, triangular.

Tergum broad, thin; tergal spur broad, short, near basiscutal angle, and rounded basally; spur width about one-half that of width of basal margin; juncture of spur with basal margin gently curved on both sides; spur furrow broad, open; articular ridge prominent, not reflexed, restricted to upper half of valve, articular furrow broad, deep; five short, well developed depressor

muscle crests depend slightly below basal margin.

DIMENSIONS:	Height	Greatest Diameter
Holotype UCMP 10929	4 mm	8.5 mm

DISPOSITION OF TYPES: Holotype and six paratypes deposited in the University of California Museum of Paleontology collection.

OCCURRENCE: Lower Pliocene, Pancho Rico Formation, UCMP loc. A-4946, on fragment of (?)schizasteroid echinoid test.

ETYMOLOGY: Subspecific epithet a compound word from the Greek *leipo*, 'without' and *choma*, 'bulwark'.

REMARKS: It is perhaps inappropriate to characterize these fossil specimens as distinct from typical *B. crenatus*. The opercular valves are unremarkable and the shell, in all features but one, is that of *B. crenatus*. However, examination of the parietal tubes of several fragmental shells associated with the type lot, and of the holotype itself revealed no trace of transverse septa; a feature characteristic of typical *B. crenatus* and its known subspecies.

The opercular valves and external shell form are easily confused with those of *B. proinus*. However, none of the over two hundred shells of *B. proinus* examined exhibited any trace of parietal tubes or of secondary cellular deposits below the dependent margin of the sheath.

Subgenus *SOLIDOBALANUS* Hoek 1913

Balanus proinus Woodring 1950

Figures 38-41

Balanus hesperius Pilsbry, var. Woodring, in Woodring, Stewart and Richards 1940:30, 97.

Balanus hesperius proinus Woodring, in Woodring and Bramlette 1950: 92, pl. 14, figs. 11, 15, pl. 16, figs. 1-3, 8-12.

Balanus proinus Woodring. Zullo 1969:16, figs. 26-32.

OCCURRENCE: UCMP locs. A-4947, A-7570.

DISTRIBUTION: Pliocene, southern California: Lower Pliocene, Pancho Rico Formation, Salinas Valley; 'Middle' Pliocene, Foxen Mudstone, Santa Maria district; Upper Pliocene, San Joaquin Formation, Kettleman Hills, Careaga Sandstone, Santa Maria district (type locality), San Diego Formation, San Diego County.

REMARKS: The specimens of *B. proinus* from the Pancho Rico Formation represents the oldest recognized occurrence of the species. It is apparently as common in Pliocene deposits of southern California as is *B. gregarius* but, because of its diminutive size, is not as well known. Shells are often found attached to pectens and occasionally to clypeasteroid echinoids and gastropods, but they have not been observed in association with other barnacles.

Balanus proinus is the youngest known member of a Tertiary tropical to warm temperate eastern Pacific group that goes back to the Late Eocene (Zullo 1966). There are no known warm water survivors, but the extant boreal Pacific species *B. hesperius* Pilsbry 1916 appears to be a derivative of this lineage.

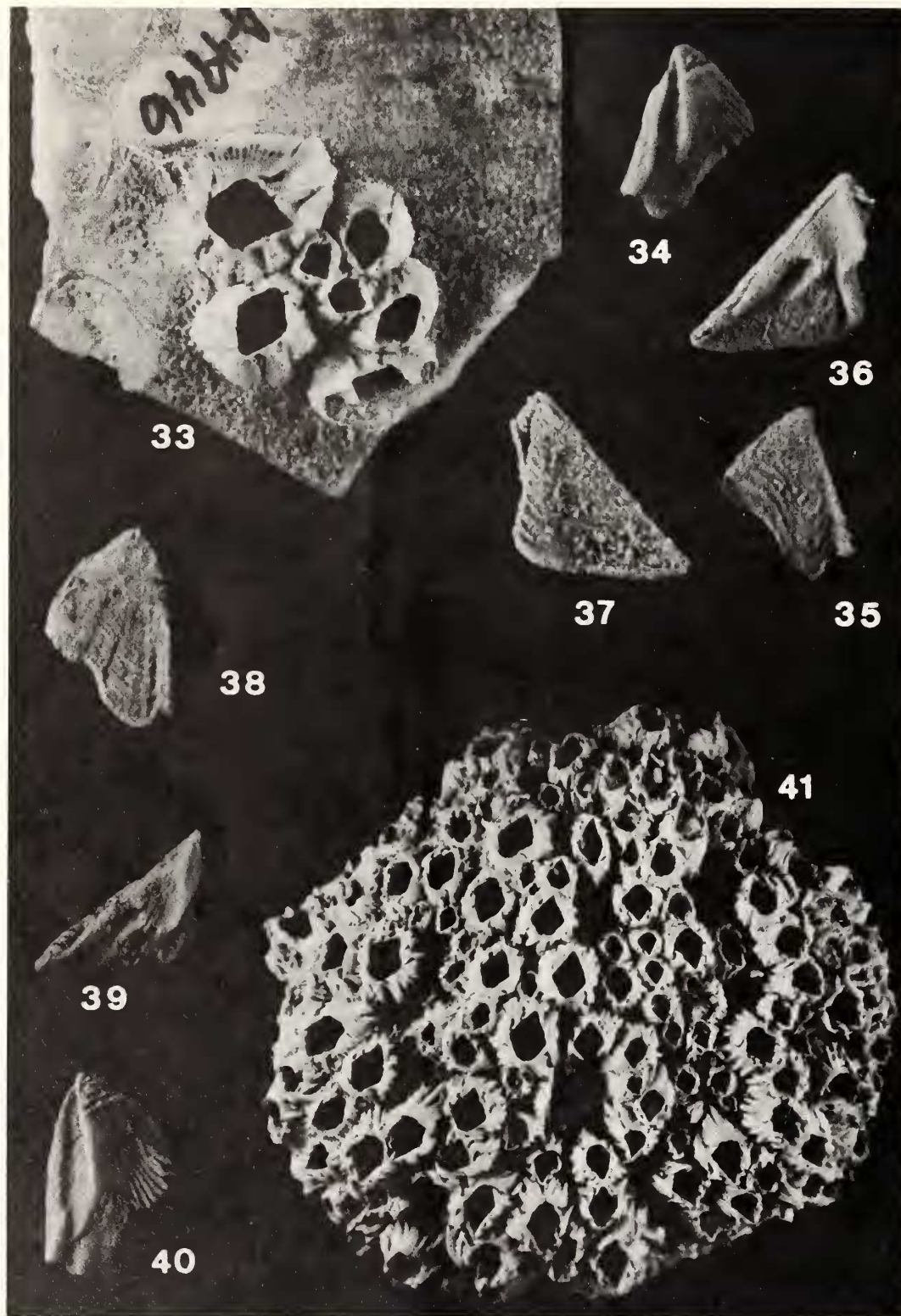
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FIGURES 33–37. *Balanus (Balanus) crenatus leipochoma*, new subspecies, UCMP loc. A-4946. (33) Shells of type lot (holotype UCMP 10929 and paratypes UCMP 10930a–f), lateral paries of holotype ground to show non-septate tubes; (34–35) tergum of holotype UCMP 10929, height, 2.1 mm; (36–37) scutum of holotype UCMP 10929, height, 2.2 mm. FIGURES 38–41. *Balanus (Solidobalanus) proinus* Woodring, UCMP loc. A-4947. (38) exterior of tergum, hypotype UCMP 10931, height, 2.5 mm, (39) interior of scutum, hypotype UCMP 10931, height, 1.6 mm; (40) interior of tergum of fig. 38; (41) group of shells on *Lyropecten estrellanus* (Conrad), hypotype lot UCMP 10932, height, 51 mm.

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